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# Computer assisted evaluation of traffic noise level

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This article presents the main aspects concerning the traffic noise as well as the elements that generate it. Starting with a study on several street profiles, the paper takes into account the variability of modelling parameters (height of buildings, distance between the façades of buildings, green zones, composition of traffic etc) and then, analyzes the influence of these factors on the traffic noise level. At the same time, it proposes a comparative study of the equivalent noise level, calculated and measured "in situ", in several boulevards of the Romanian capital city, Bucharest.

## INTRODUCTION

All the surveys and investigations agree: more than half of the citizens consider the noise as first rank harmful effects which they undergo. The noise of the urban road traffic dominates the city and even if it does not have any direct influence on the humans, because the levels are not high enough to produce deafness, in the case of prolonged exposure, it is, nevertheless, harmful when it is too annoying [1]. It obstructs the conversations, prevents the normal listening to the radio, the telephone and television, reduces attention and decreases the quality of the sleep. One can act, by technical means, against the noise in several directions, of which we could mention: acoustic baffles and improving of the carriageway surfacing.

## 1. FACTORS WHICH GENERATE TRAFFIC NOISE

The influence of the road surface on the traffic noise is a current problem for the urban engineers because the noise is prejudicial to people; the urban zones are thus most critical with respect to this harmful effect [2]. The requirement of the standards reacting to the total noise emitted by vehicles led the manufacturers to strongly decrease the mechanical noises.

The noises of exhaust, intake, transmission and ventilators have been very seriously reduced by the use of more effective silencers or by the use of performing systems of ventilation. The noise level due to the traffic is related to several factors [3–5]:

- flow of light vehicles;
- flow of heavy lorries;
- speed of traffic;
- slope of way;
- characteristics of traffic, whether constant or for the duration of peak hours;
- geometry of way;
- characteristics of road surface.

In order to decrease the traffic noise, it is not possible to modify the geometric elements of the way. In addition, as the heavy lorries have mostly been eliminated from the centers of the cities, one will not make any more changes to the other parameters related to the traffic for the only reason of the noise. There is even a tendency to increase flow of traffic. With these data, there remains only the road surface factor on which it is possible to intervene in order to modify the sound environment in the streets.

## 2. INFLUENCE OF COATING (ROAD SURFACE)

To determine the influence of various coatings on the sound level by the tyre-track contact [6], one should take into account the tyre, the coating, the speed of the vehicle and the humidity of the roadway. It is essential to know the limit to which the tyre noise becomes dominating compared to the total noise of the vehicle. If this limit is below 60 Km/h, the actions on the road coatings could be beneficial in decreasing the traffic noise. It has been noticed that from 40 Km/h, the difference between the total noise and the rolling noise is 3 dB(A), i.e. the acoustic intensity of the tyre noise is equal to that of the other noises. Between 50 and 60 Km/h, this difference, lower than 3 dB(A), shows that the rolling noise becomes dominating.

One can say that the coating has a notable influence on the traffic sound, even at urban speeds.

With regard to the coatings, one observes a notable difference between the draining coatings and the traditional asphaltic concretes. The draining coatings are bituminous mixes with more than 20% of porosity which was designed for a fast drainage of surface water. It has been noticed that on these coatings the traffic sound is much lower than on traditional bituminous mix, with a significant variation from 4 to 7 dB(A). This variation could be explained by the reduction of the tyre/track contact noise and by the effect of absorption which this type of coating presents.

## 3. PARAMETERS WHICH INFLUENCE THE LEVEL OF TRAFFIC NOISE

The index adopted for the road noise is the equivalent noise level $L_{eq}$ at 2 m in front of the façades rows of the buildings and 1.50 m above the ground [7]. The $L_{eq}$ between 8 h and 18 h is not very variable, it is practically not affected by the increase of traffic at the peak hour. The diurnal $L_{eq}$ between 8 h and 20 h is very close (except for less than 1 dB) to the $L_{eq}$ of 11 h to 12 h. The noise level decreases in the evening from 20 h to 24 h, much more slowly close to the large highways especially when the traffic of heavy lorries occurs in the evening. Night silence is very short, about 4–5 hours long, however, there is a heavy traffic within this interval; the $L_{eq}$ is then lower by only 10 dB to the diurnal $L_{eq}$ whereas the former can be lower than the latter by 20 dB in the calm ways [8–9]. The increase of the traffic noise level in the morning is more stressful than its fall in the evening.

In the case of the road traffic, the level $L_{eq}$ depends on several factors:

- the height of the buildings bordering the way;
- the distance between the façades rows of the buildings;
- flow and type of vehicles;

- the number of lanes;
- the type of coating;
- the existence of green zones

and the noise level produced by a source I in point A [7] is calculated with the following relation:

$$L_{eq}^{A} = L_{i}^{I} + 10\lg\left\{\frac{1}{\left[\left(\frac{d}{d_0}\right)^{\frac{k}{10}} c_s c_{zv}\right]} + \frac{1}{\left(\frac{d'-d}{d_0}\right)^{\frac{k'}{10}}}\left[\frac{1-\alpha_1}{\left(\frac{d'}{d_0}\right)^{\frac{k}{10}}} + \frac{\frac{(1-\alpha_1)(1-\alpha_2)}{c_s c_{zv}}}{\left(\frac{D-d'}{d_0}\right)^{\frac{k}{10}}\left(\frac{D}{d_0}\right)^{\frac{k'}{10}}}\right]\times\right.$$

$$\left.\times\frac{\left(\frac{D}{d_0}\right)^{\frac{k'}{5}}}{\left[\left(\frac{D}{d_0}\right)^{\frac{k'}{5}} - (1-\alpha_1)(1-\alpha_2)\right]c_s c_{zv}}\right\}, \qquad (1)$$

where

*d* is the distance from the sound source E to the measuring place A;

*d'* – distance from the sound source E to the front of the building close to which measuring is carried out;

*D* – width between fronts of buildings;

*d*, *d'* and *D* are shown in figure 1;

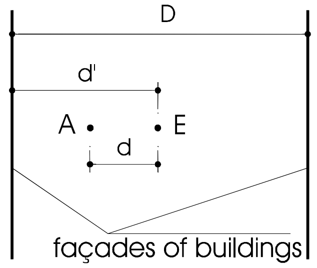


Fig. 1

$L_i^I$ corresponds to only one type I of vehicle which circulates on one lane;

$d_0$ – 1 m;

$c_s$ – coefficient taking into account the nature of surfacing (0.90 – for asphalt coated road and 0.85 – for paved road) ;

$c_{zv}$ – coefficient taking into account the green zones (see Table 1), function of the season (w – winter and s – summer);
$k$ – directivity coefficient of source, considered as being normal to the building façade ($k$ = 10, for usual road traffic);
$k'$ – directivity coefficient of reflected waves between the façades of buildings;
$\alpha_1$ – absorption coefficient of building façade placed on the same side of the road where the measuring point is;
$\alpha_2$ – absorption coefficient of building façade placed on the opposite side of the road where the measuring point is.

The noise level in point A [7], coming from several types of vehicles circulating on several lanes becomes:

$$L_{ext}^{A} = 10\lg\left(\frac{1}{T}\sum_{1}^{n} t_I 10^{\frac{L_I^A}{10}}\right), \quad (2)$$

where
$T$ is the characteristic duration (for example, 3600 s);
$t_I$ – duration corresponding to action I in the investigated point;
$L_I^A$ – the noise level corresponding to I action.

## 4. CASE STUDY

The applications, which we have calculated constitute real cases analyzed within the framework of a scientific co-operation with the Romanian Civil Engineering Research Institute INCERC of Bucharest. The transverse profiles of the streets are presented in figure 2 and the input data are in the following table:

Table 1

| | $k'$ | $D$ | Composition of traffic (urban transp.lines / no. of vehicles/one way) | | | | | $c_s$ | $L_{eq}^A$, dB(A) calculated | | | $L_{eq}^A$, dB(A) measured |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | auto | tram | t-bus | bus | trucks | road coating | $c_{zv}$ = 1 | $c_{zv}$ – w | $c_{zv}$ – s | |
| 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
| 1 | 0 | 43 | 500 | 21/30 | 11/25 | 21/50 | - | 0.90 | 78.60 | 77.15 | 74.40 | 80 |
| | | | | | | | 200 | 0.90 | 85.05 | 83.60 | 81.30 | 84 |
| 2 | 5 | 43 | 500 | 21/30 | 11/25 | 21/50 | - | 0.90 | 65.85 | 64.10 | 62.40 | 65 |
| | | | | | | | | 0.85 | 68.20 | 67.20 | 64.75 | - |
| 3 | 5 | 83 | 500 | 21/30 | 11/25 | 21/50 | - | 0.90 | 63.20 | 62.20 | 59.70 | 61 |
| | | | | | | | | 0.85 | 65.20 | 64.20 | 61.70 | - |

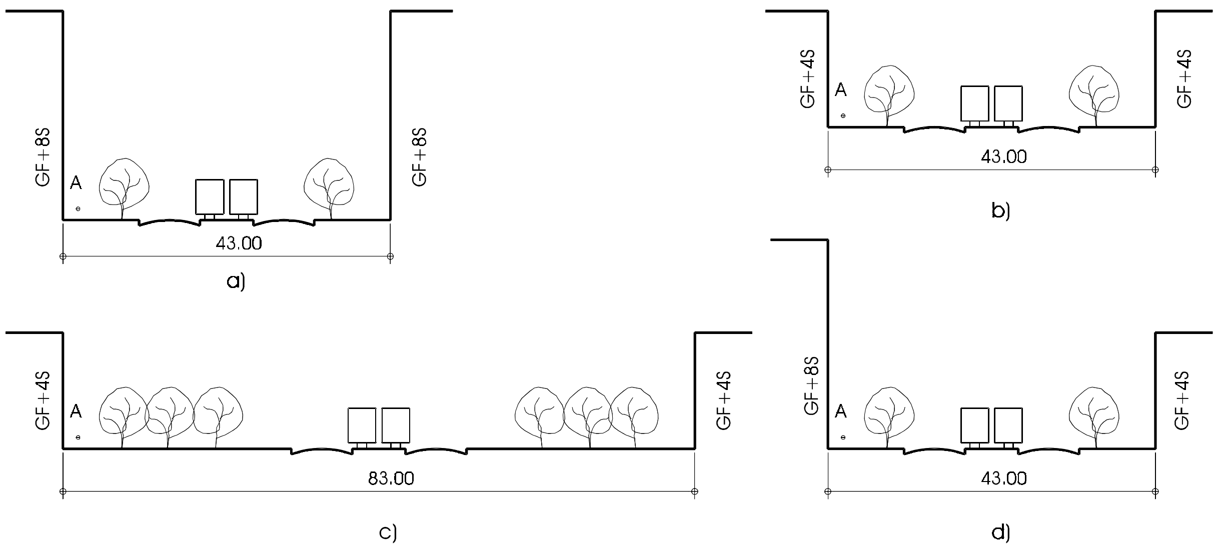


Fig. 2. Transversal profiles of ways
Multi-storied buildings, GF+nS, where GF – ground floor and nS – number of stories

We have considered several infrastructures of circulation (asphalt coated and paved streets) composing several lanes (3), circulated in double direction, bordered by quasi-continuous rows of buildings on both sides of the lanes. In order to explain the influence of the factors, which determine the traffic acoustic regime, a comparative study of several alternatives for the transverse profile of a way has been made. The following factors were analyzed:

- the height of the buildings which border the lane;
- the distance between buildings;
- the type of coating;
- the existence of green zones;
- the composition of traffic.

The calculation of the level $L_{eq}$ was carried out using the software URBAN2 made by INCERC Institute of Bucharest. The software program is a very fast and useful instrument, which can consider several alternatives of ways, having additional options relating to the introduction of the input data, the types of vehicles etc. Table 1 shows clearly that:

- the reduction from nine to five stories in height of the buildings bordering the way, leads to the decrease by more than 10 dB(A) of the noise level (fig. 2b);

- in the case of the bordered ways on the one side by nine storey-high buildings (GF+8S) and on the other side by five story-high buildings (GF+4S), the level of road noise decreases by 12 to 15 dB(A) as compared to the U-shaped streets bordered by buildings GF+8S (fig. 2d);

- the surfacing type decreases by 2 to 4 dB(A) the level of traffic noise, in the case of the asphalt coated ways compared to the paved ones;

- the green zones decrease the noise level by 1…3 dB(A), taking account of the season (summer-winter);

- the enlarging of the width of the way (from 43 m to 83 m) leads to the reduction of the traffic noise level by 2…3 dB(A) (fig. 2c);

- the influence of the heavy traffic leads to the increase by more than 6 dB(A) of the traffic sound level.

## 5. CONCLUSIONS

From the acoustic study concerning 42 traffic ways in Romania's capital city, Bucharest, three representative cases have been selected, in order to emphasize the influence of the urban geometrical parameters and of traffic on the level of traffic noise. Results of measures "in situ" carried out for the selected boulevards show that for five storey-high buildings the relation $L_{eq}^{A}$ ≤ 70 dB(A) is true, but, in the case of multi-storied buildings (GF+8S) the $L_{eq}^{A}$ level is exceeded by far. In this case, we consider necessary to take active and passive protection measures against the urban noise, by taking into account the structure and wear of the coating of the traffic way, the use of acoustic baffles [10] etc.

One can see that the measurements made in the field agree to a great extent with the results of the equivalent traffic noise level obtained by URBAN2 software program, which confirms the utility of this instrument.

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